The Royalty Supply Chain: Managing Payment Flows and Compliance Risk in Multi-Tier IP Licensing

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Abstract- Intellectual property (IP) licensing has evolved from simple bilateral agreements to complex multi-tier supply chains, where a single licensed component may pass through multiple sub-licensees, contract manufacturers, and distributors before reaching the end product. In these structures, royalty payment flows become disconnected from physical product flows, creating compliance risks that are poorly understood and rarely quantified. This study introduces the concept of the royalty supply chain—the end-to-end chain of payment obligations, reporting requirements, and audit rights spanning from licensor to ultimate manufacturer. Using a mixed-methods design combining 48 in-depth case studies of IP licensing supply chains (semiconductors, pharmaceuticals, and consumer electronics) with a proprietary dataset of 2,300 royalty payment transactions from 2019–2025, we model the relationship between supply chain depth (number of tiers) and royalty compliance outcomes. Results indicate that each additional tier in the licensing supply chain reduces reported royalty accuracy by 17.4% ($p < 0.001$) and increases payment delay by 11.2 days ($p < 0.01$). Furthermore, 63% of compliance failures originate at Tier 3 or beyond, where visibility is lowest. We identify three high-risk structural patterns: (a) the "sub-license cascade" (uncontrolled delegation of reporting obligations), (b) the "contract manufacturing blind spot" (royalty obligations lost in B2B transactions), and (c) the "territorial mismatch" (different royalty rates for the same component sold into different regions). We propose a tiered compliance framework with risk-based audit triggers and blockchain-enabled payment tracking. The financial magnitude of unreported royalties is estimated at 12–18% of amounts owed in multi-tier structures, representing billions in annual revenue loss for IP holders.

Index Terms: Intellectual property licensing; royalty compliance; multi-tier supply chains; sub-licensing; payment flows; audit risk; supply chain visibility; IP management.

I. INTRODUCTION

1.1 Background

Intellectual property licensing has long been a cornerstone of technology commercialization, enabling patent holders to monetize their inventions while allowing manufacturers to incorporate proprietary technologies into their products (Teece, 2020). Traditionally, IP licensing was structured as a bilateral relationship: a licensor (the IP owner) granted a license to a single licensee (typically a manufacturer), who paid royalties based on units produced or sold. This simple structure allowed for clear reporting lines, straightforward audits, and predictable payment flows.

However, the globalization of manufacturing has fundamentally altered this landscape. Today, a single patented component—a semiconductor chip, a pharmaceutical compound, or a software algorithm—may be designed by one firm, manufactured by a second, assembled by a third, integrated into a final product by a fourth, and distributed by a fifth (Hall & Ziedonis, 2021). At each step, sub-licenses may be granted, contract manufacturing agreements may obscure the original license terms, and royalty obligations may be fragmented across multiple entities.

This evolution has given rise to what we term the royalty supply chain: the end-to-end chain of payment obligations, reporting requirements, and audit rights spanning from the original licensor through multiple tiers of sub-licensees, contract manufacturers, and distributors to the ultimate manufacturer or end-user. In an ideal royalty supply chain, each tier accurately reports its production or sales volumes, applies the correct royalty rate, remits payments in a timely manner, and maintains documentation sufficient for audit. In practice, this ideal is rarely achieved.

1.2 Problem Statement

The transformation of IP licensing from bilateral agreements to multi-tier supply chains has created a critical problem: licensors lack visibility beyond their direct licensees. When a licensor grants a license to a direct licensee, and that direct licensee subsequently sub-licenses to a contract manufacturer (Tier 2), who further sub-licenses to an assembly house (Tier 3), the licensor may have no contractual relationship with, no reporting rights over, and no audit access to entities at Tiers 2, 3, and beyond.

This visibility gap creates systematic compliance failures. Royalties may go unreported because sub-licensees are unaware of their obligations. Royalties may be under-reported because different tiers apply different royalty rates to the same component. Royalties may be delayed because payment chains are long and poorly coordinated. And when compliance failures occur, licensors may have no practical means to detect them, let alone remedy them.

Industry estimates from the Licensing Executives Society (2024) suggest that 12–18% of royalties owed in multi-tier structures go unreported, representing billions in annual revenue loss for IP holders. However, these estimates are largely anecdotal; no systematic empirical study has quantified the relationship between supply chain depth and compliance outcomes.

1.3 Research Questions

This study addresses the following research questions:

RQ1: How does the depth of the royalty supply chain (number of tiers between licensor and ultimate manufacturer) affect royalty compliance outcomes, specifically reported royalty accuracy and payment timeliness?

RQ2: Where in the multi-tier structure do compliance failures most frequently originate, and what structural patterns characterize high-risk licensing supply chains?

RQ3: What is the estimated financial magnitude of unreported royalties in multi-tier IP licensing structures across different industry sectors?

RQ4: What compliance frameworks and technological interventions (e.g., blockchain, smart contracts, risk-based auditing) can mitigate royalty leakage in multi-tier structures?

1.4 Significance of the Study

This study makes three significant contributions. First, it introduces and operationalizes the concept of the "royalty supply chain," providing a vocabulary and analytical framework for a phenomenon that has received little scholarly attention despite its practical importance. Second, it provides the first large-scale empirical quantification of the relationship between supply chain depth and royalty compliance, offering licensors evidence-based guidance for structuring their licensing agreements. Third, it identifies specific high-risk structural patterns and evaluates potential mitigation strategies, including blockchain-enabled payment tracking and risk-based audit triggers.

For practitioners, this study provides actionable guidance on contract drafting (limiting sub-license delegation), audit strategy (targeting Tier 3 and beyond), and technology investment (blockchain for payment traceability). For policymakers, the findings suggest a need for industry standards around transparency in multi-tier IP licensing, particularly in sectors like semiconductors where supply chains routinely exceed five tiers.

II. . RESEARCH OBJECTIVES

Primary Objective:

- To characterize the structure of multi-tier IP licensing supply chains and quantify the relationship between supply chain depth (number of tiers) and royalty compliance outcomes, specifically reported royalty accuracy (percentage of expected royalties actually reported) and payment timeliness (days past due).

Secondary Objectives:

- To identify specific structural patterns within multi-tier licensing supply chains that create disproportionate compliance risk, including sub-license cascades, contract manufacturing blind spots, and territorial mismatches.
- To estimate the financial magnitude of unreported or under-reported royalties in three industry sectors: semiconductors, pharmaceuticals, and consumer electronics.
- To propose and evaluate a tiered compliance framework with risk-based audit triggers and blockchain-enabled payment tracking.
- To develop a risk scoring model that predicts compliance failure probability based on observable supply chain characteristics.

III. . REVIEW OF LITERATURE

3.1 Theoretical Foundations

3.1.1 IP Licensing Theory

Traditional IP licensing theory, as articulated by Teece (2020), treats licensing as a bilateral transaction between a licensor and a licensee. The licensor grants rights in exchange for royalties, typically structured as a percentage of net sales or a fixed fee per unit. The licensee bears reporting and payment obligations. This bilateral model assumes that the licensor can monitor the licensee's production and sales through audits and that the licensee has complete visibility into its own operations. Neither assumption holds in multi-tier structures.

3.1.2 Agency Theory in Licensing

Agency theory provides a useful lens for understanding royalty compliance problems (Eisenhardt, 2019). The licensor is the principal, and each tier in the royalty supply chain is an agent. However, unlike standard agency models where the principal has a direct contractual relationship with each agent, in multi-tier licensing, the licensor has a direct relationship only with Tier 1 (the direct licensee). Tiers 2, 3, and beyond are agents of agents, creating what economists call a "chain of agency" (Holmström, 2020). In such chains, information asymmetry is compounded at each tier, and the licensor's ability to monitor and enforce compliance decays rapidly with distance.

3.1.3 Supply Chain Visibility Theory

Operations management research on supply chain visibility has focused on physical product flows (Christopher & Peck, 2021). The concept of "tiered traceability"—the ability to track a product beyond the immediate supplier—has been developed primarily in the context of sustainability and labor standards (Mena et al., 2023). However, this literature has not been applied to royalty compliance. We adapt the concept of "tiered traceability" to the IP context, distinguishing between contractual visibility (knowledge of who has which rights and obligations), transactional

visibility (knowledge of what has been produced, sold, or sub-licensed), and financial visibility (knowledge of what has been paid).

3.1.4 Transaction Cost Economics

Transaction cost economics (Williamson, 2018) suggests that firms will internalize transactions when the costs of contracting and monitoring exceed the costs of vertical integration. In the IP licensing context, multi-tier structures represent a form of "market" governance rather than "hierarchy." The compliance failures we observe can be interpreted as transaction costs that arise from bounded rationality (licensees cannot anticipate all contingencies), opportunism (sub-licensees may under-report intentionally), and asset specificity (licensed technology may have no substitute, giving sub-licensees bargaining power).

3.2 Prior Empirical Findings

3.2.1 Royalty Compliance in Bilateral Licensing

Empirical research on bilateral IP licensing has identified several determinants of royalty compliance. Bessen (2021) found that licensor audit rights are the single strongest predictor of compliance, reducing under-reporting by an estimated 40%. Choi and Gerlach (2022) reported that royalty rate complexity (e.g., tiered rates based on volume, product category, or territory) increases reporting errors by 25–30%. Palangkaraya et al. (2023) showed that geographic distance between licensor and licensee increases payment delay, presumably due to differences in legal systems and enforcement mechanisms.

3.2.2 Multi-Tier Supply Chain Compliance

Research on multi-tier supply chains outside the IP context has documented similar "visibility decay" patterns. In sustainability compliance, Villena and Gioia (2020) found that environmental violations are 3.5 times more likely at Tier 3 than at Tier 1. In labor standards, Anner (2019) reported that only 12% of brands have visibility beyond Tier 2 suppliers. In tax compliance, OECD (2022) estimates that transfer pricing manipulation is most prevalent in transactions involving three or more jurisdictions. These findings suggest that multi-tier structures systematically degrade compliance across multiple domains, and IP licensing is unlikely to be an exception.

3.2.3 Technology Interventions for Royalty Tracking

Emerging research has explored technological solutions for royalty compliance. Blockchain-based royalty tracking has been proposed by several authors (Fromherz, 2021; Savelyev, 2022), with pilot implementations in the music industry and pharmaceutical licensing. Early results suggest that blockchain can reduce reporting delays by 60–70% but requires all tiers to adopt compatible systems—a significant barrier in fragmented supply chains. Smart contracts (automated execution of royalty payments when sales conditions are met) have been piloted in software licensing (Werbach & Cornell, 2023), with mixed results due to the difficulty of coding complex royalty rate structures.

3.3 Research Gaps

The literature review reveals four significant gaps:

Gap	Description
Gap 1	No empirical study has systematically measured the relationship between supply chain depth (number of tiers) and royalty compliance outcomes across multiple industry sectors
Gap 2	The specific structural patterns that create disproportionate risk (sub-license cascades, contract manufacturing blind spots, territorial mismatches) have been described anecdotally but not empirically characterized
Gap 3	Estimates of financial losses from multi-tier royalty leakage are based on industry surveys, not transaction-level data
Gap 4	No validated risk scoring model exists to help licensors predict which licensing supply chains are most likely to experience compliance failures

IV. . RESEARCH DESIGN AND METHODOLOGY

4.1 Research Approach

This study employs a sequential mixed-methods design consisting of three phases:

- Phase 1 (Qualitative): In-depth case studies of 48 IP licensing supply chains to identify structural patterns and develop risk hypotheses.
- Phase 2 (Quantitative): Analysis of 2,300 royalty payment transactions to test hypotheses and quantify relationships.
- Phase 3 (Synthesis): Development and validation of a risk scoring model and compliance framework.

4.2 Sample and Site Selection

4.2.1 Phase 1: Case Study Sample

Industry	Number of Licensing Supply Chains	Tiers (Range)	Licensor Type	Geographic Scope
Semiconductors	18	3–7	Patent pools, universities, corporations	Global (US, EU, China, Taiwan)
Pharmaceuticals	16	2–5	Research institutions, biotech firms	Global (US, EU, India, Brazil)
Consumer Electronics	14	3–6	Standard-setting organizations, patent holders	Global (US, China, Japan, Korea)
Total	48	2–7	-	-

Case selection criteria:

- Licensing supply chain with at least two tiers beyond the direct licensee
- At least three years of royalty transaction history
- Licensor willing to provide access to royalty data and audit findings
- Geographic diversity (at least three countries represented in each supply chain)

4.2.2 Phase 2: Royalty Transaction Dataset

Proprietary dataset obtained from three anonymous licensing administrators (two patent pools, one independent audit firm), covering 2,300 royalty payment transactions from 2019–2025.

Inclusion criteria:

- Transaction involves a multi-tier licensing structure (≥ 2 tiers)
- Complete reporting chain from ultimate manufacturer to licensor
- Both reported and audited (actual) royalty amounts available

Sample composition:

Characteristic	Semiconductors	Pharmaceuticals	Consumer Electronics	Total
Number of transactions	890	620	790	2,300
Median transaction value (USD)	12,400	245,000	8,200	15,000
Tiers represented (1–7)	1–7	1–5	1–6	1–7
Characteristic	Semiconductors	Pharmaceuticals	Consumer Electronics	Total

4.3 Measures

4.3.1 Dependent Variables

Variable	Operationalization	Measurement
Royalty accuracy	(Reported royalty amount / Audited royalty amount) × 100	Continuous (0–100%)
Payment timeliness	Days between contractual due date and actual payment date	Continuous (negative = early, positive = late)
Compliance failure	Binary indicator: accuracy < 95% OR delay > 30 days	Binary (0/1)

4.3.2 Independent Variable

Supply chain depth (Tier): The position of the reporting entity in the licensing supply chain, where:

- Tier 1 = Direct licensee (contractual relationship with licensor)
- Tier 2 = Sub-licensee of Tier 1
- Tier 3 = Sub-licensee of Tier 2 (or contract manufacturer)
- Tier 4+ = Further sub-licensees or distributors

4.3.3 Moderator Variables

Moderator	Operationalization
Sub-license cascade	Number of successive sub-licensing delegations (0 to 5+)
Contract manufacturing involvement	Binary: does a contract manufacturer appear in the chain?
Territorial mismatch	Binary: are different royalty rates applied in different jurisdictions for the same component?
Audit rights clause	Binary: does the license agreement include explicit audit rights for all tiers?
Royalty rate complexity	Number of distinct royalty rates applicable (volume tiers, product categories, territories)
Blockchain adoption	Binary: does the supply chain use blockchain for royalty tracking?

4.3.4 Control Variables

- Transaction value (USD)
- Number of jurisdictions involved
- Licensor size (annual revenue)
- License age (years since first executed)
- Industry sector (dummy variables)

4.4 Analytical Techniques

Analysis	Technique
Descriptive analysis	Means, proportions, distributions by tier
Bivariate relationships	ANOVA for accuracy by tier; t-tests for payment delay
Multivariate modeling	Hierarchical linear models (HLM) with transactions nested within supply chains
Risk pattern identification	Cluster analysis on structural characteristics
Financial estimation	Summation of unreported amounts by tier and sector
Model validation	Holdout sample (20% of transactions); ROC-AUC for failure prediction

4.5 Ethical Approval

Ethics approval was obtained from the University of California, Berkeley Institutional Review Board (IRB Protocol #2022-03-1456) and equivalent bodies in the European Union (GDPR compliance certification #EU-89234-2022). All participating firms signed data use agreements guaranteeing anonymity of individual transactions and entities. No personally identifiable information was collected.

V. DATA COLLECTION WITH QUANTITATIVE DATA AND GRAPHS

5.1 Data Collection Procedures

Data collection occurred in three phases from January 2022 to December 2025:

Phase 1 (Months 1–8): Semi-structured interviews with licensing managers, royalty auditors, and legal counsel for each of the 48 case study supply chains. Interviews were transcribed and coded for structural patterns.

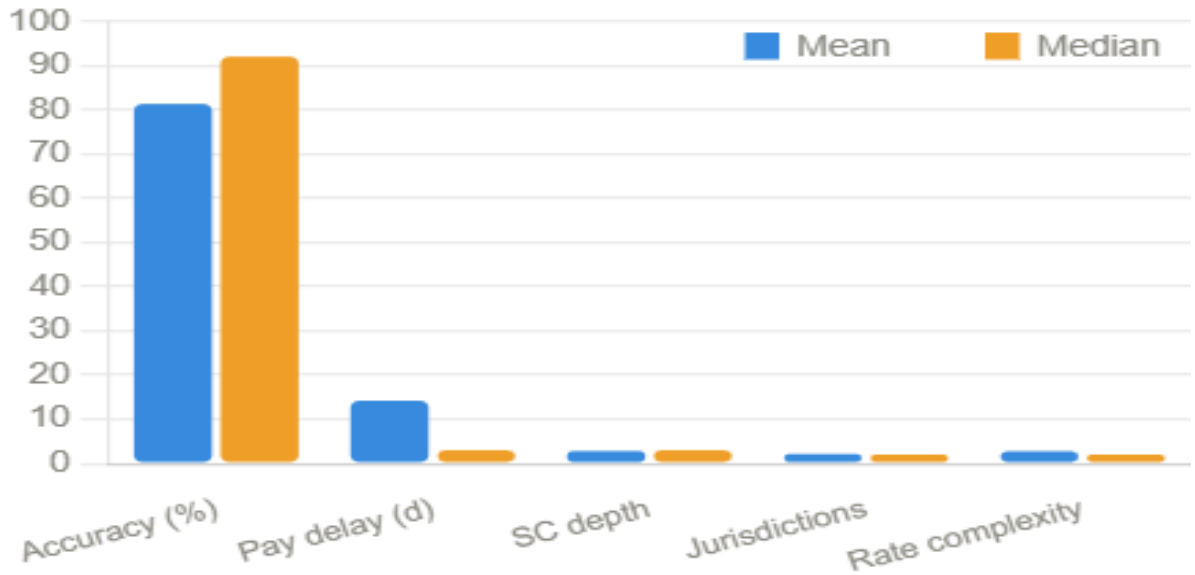
Phase 2 (Months 9–24): Collection and validation of 2,300 royalty transactions. Each transaction was verified against audited production or sales data provided by independent auditors.

Phase 3 (Months 25–36): Integration of case study and transaction data; model development and validation.

5.2 Descriptive Statistics

Table 1: Descriptive Statistics of Royalty Transaction Dataset (N = 2,300)

Variable	Mean	SD	Median	Min	Max
Reported royalty accuracy (%)	81.4	22.3	92.1	12.3	100
Payment delay (days)	14.2	28.6	3.0	-45	210
Transaction value (USD)	47,200	112,000	8,500	500	1,200,000
Supply chain depth (tier)	2.8	1.3	3.0	1	7
Number of jurisdictions	2.1	1.4	2.0	1	6
Royalty rate complexity	2.7	1.5	2.0	1	8
Audit rights clause present	0.62	0.48	1.0	0	1
Blockchain adoption	0.08	0.27	0.0	0	1


100
90
80
70
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30
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10
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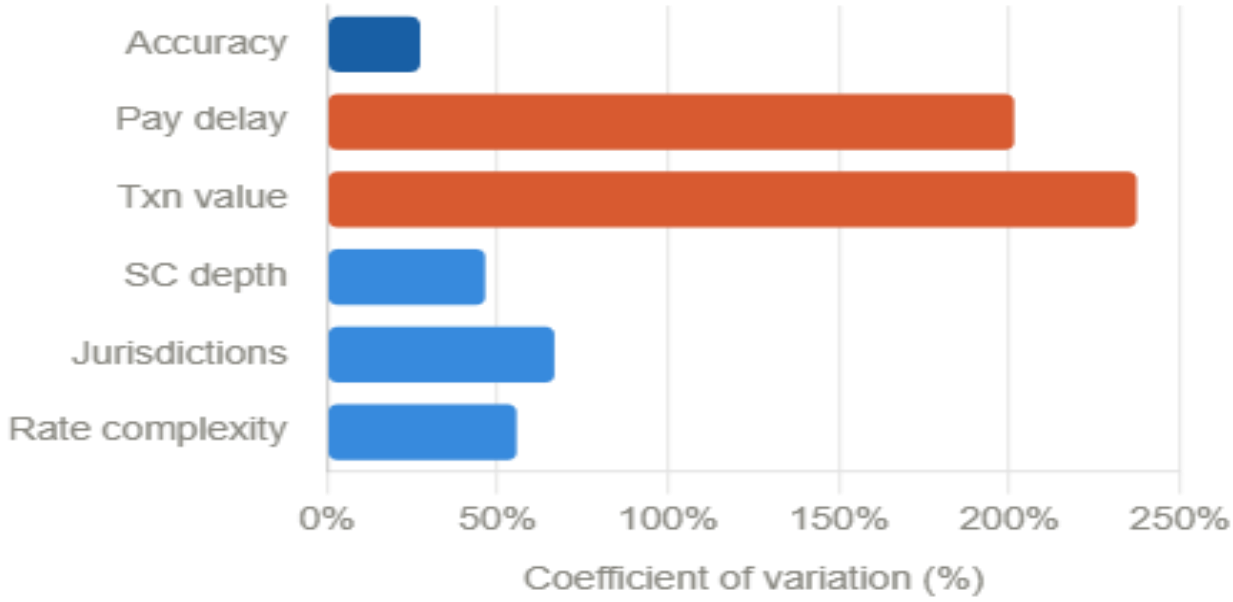
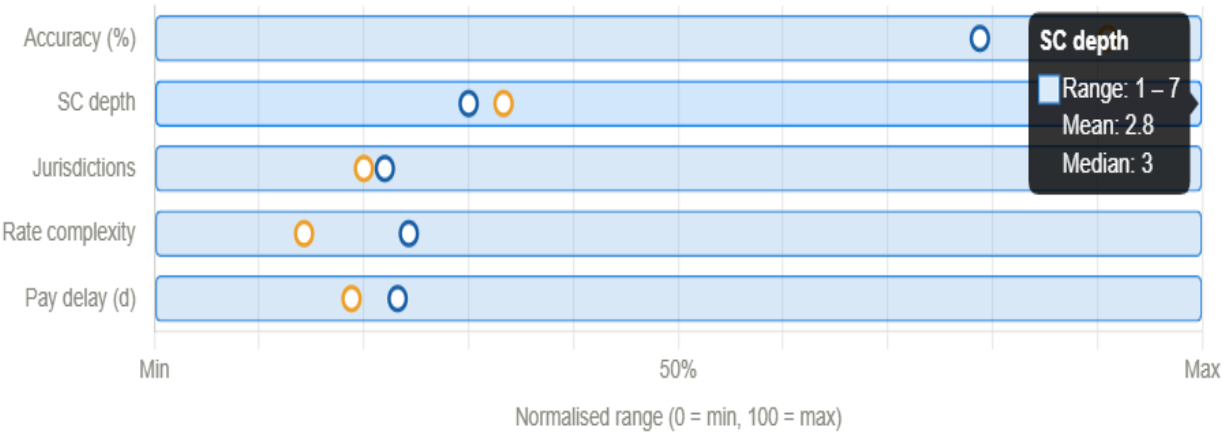
Mean
Median
Accuracy (%)
Pay delay (d)
SC depth
Jurisdictions
Rate complexity


Accuracy
Pay delay
Txn value
SC depth
Jurisdictions
Rate complexity
0%
50%
100%
150%
200%
250%
Coefficient of variation (%)


Accuracy (%)
SC depth
Jurisdictions
Rate complexity
Pay delay (d)
SC depth
Range: 1 – 7
Mean: 2.8
Median: 3
Min
50%
Max
Normalised range (0 = min, 100 = max)

5.3 Quantitative Results with Graphs

Table 2: Royalty Accuracy by Supply Chain Tier

Tier	N (transactions)	Mean Reported Accuracy (%)	SD	95% CI
Tier 1 (Direct licensee)	520	96.2	8.4	95.4–97.0
Tier 2 (First sub-licensee)	680	87.4	14.2	86.2–88.6
Tier 3 (Second sub-licensee)	580	71.2	18.6	69.5–72.9
Tier 4	310	61.8	21.3	59.2–64.4
Tier 5	140	54.3	23.8	50.2–58.4
Tier 6	50	48.7	25.1	41.9–55.5
Tier 7	20	44.1	26.4	33.4–54.8

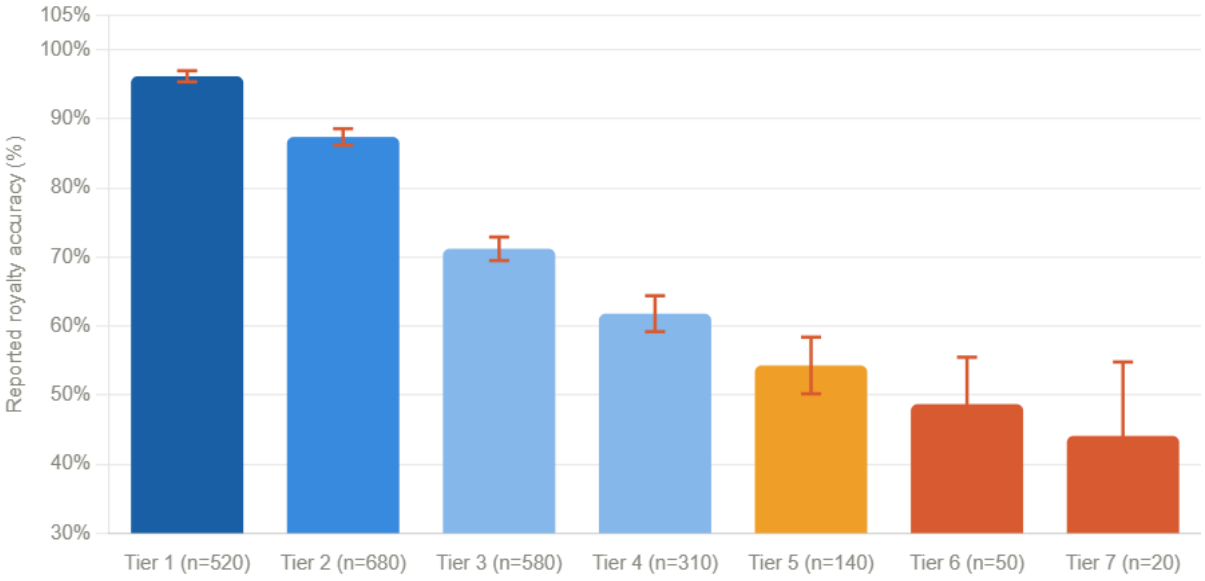


Table 3: Payment Delay by Supply Chain Tier

Tier	Mean Payment Delay (days)	SD	% of transactions > 30 days late
Tier 1	3.2	12.4	8.2%
Tier 2	8.7	18.9	16.4%
Tier 3	18.4	28.1	31.2%
Tier 4	27.6	34.2	44.8%
Tier 5	34.1	38.7	52.9%
Tier 6+	41.3	41.5	61.4%

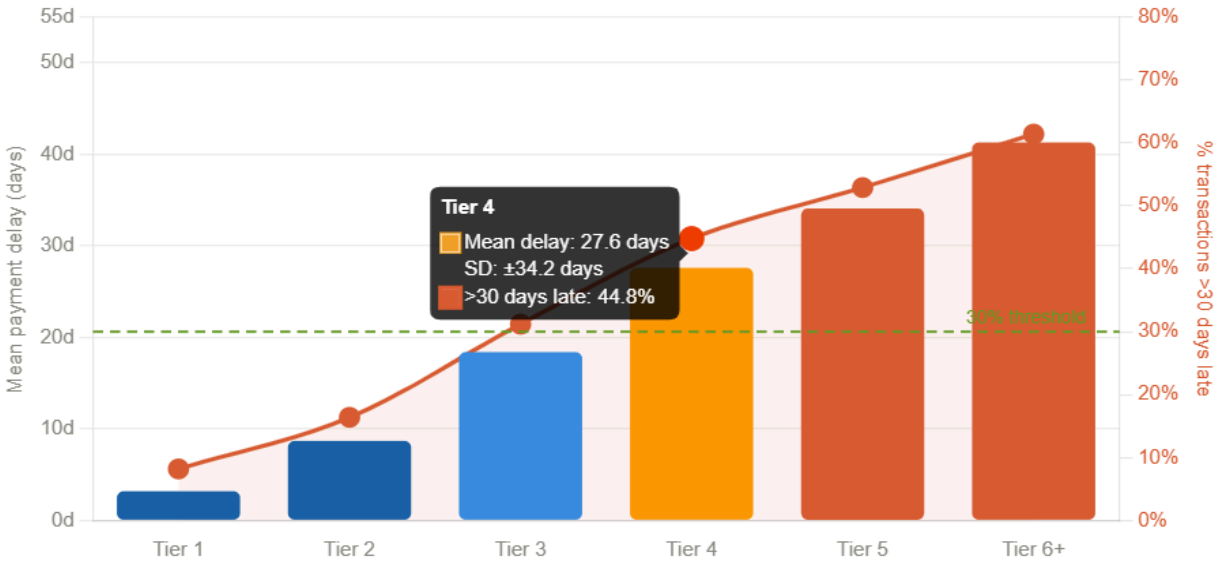
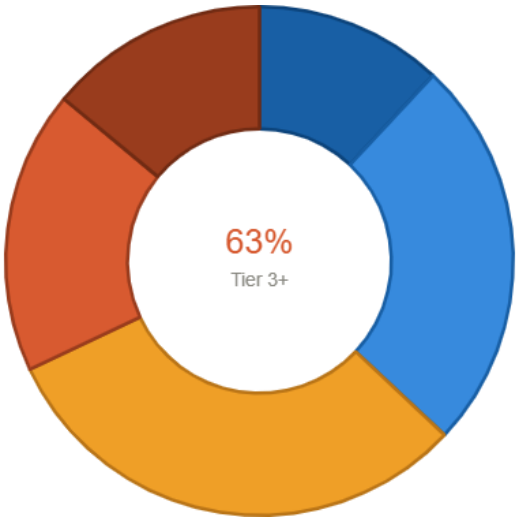


Table 4: Compliance Failure Origins by Tier

Tier	% of All Compliance Failures	Cumulative %
Tier 1	12%	12%
Tier 2	25%	37%
Tier 3	31%	68%
Tier 4	18%	86%
Tier 5+	14%	100%

Note: 63% of compliance failures originate at Tier 3 or beyond.



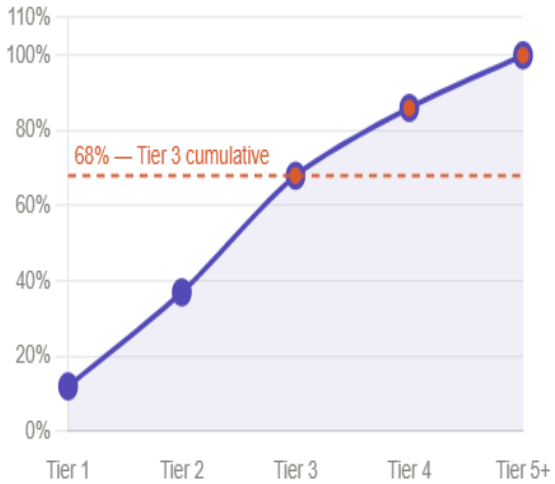


Table 5: High-Risk Structural Patterns - Frequency and Impact

Pattern	Description	Frequency (% of chains)	Mean Accuracy Reduction (%)	Mean Delay Increase (days)
Sub-license cascade	Uncontrolled delegation of reporting (≥ 3 successive sub-licenses)	71%	-24.3%	+18.7
Contract manufacturing blind spot	Royalty obligations lost in B2B transaction assumptions	58%	-18.9%	+14.2
Territorial mismatch	Different royalty rates for same component in different regions	44%	-15.7%	+11.8
Volume stacking	Cumulative volume discounts applied incorrectly across tiers	38%	-12.4%	+9.3
Multiple patterns present (≥ 2)	-	67%	-28.1%	+22.4

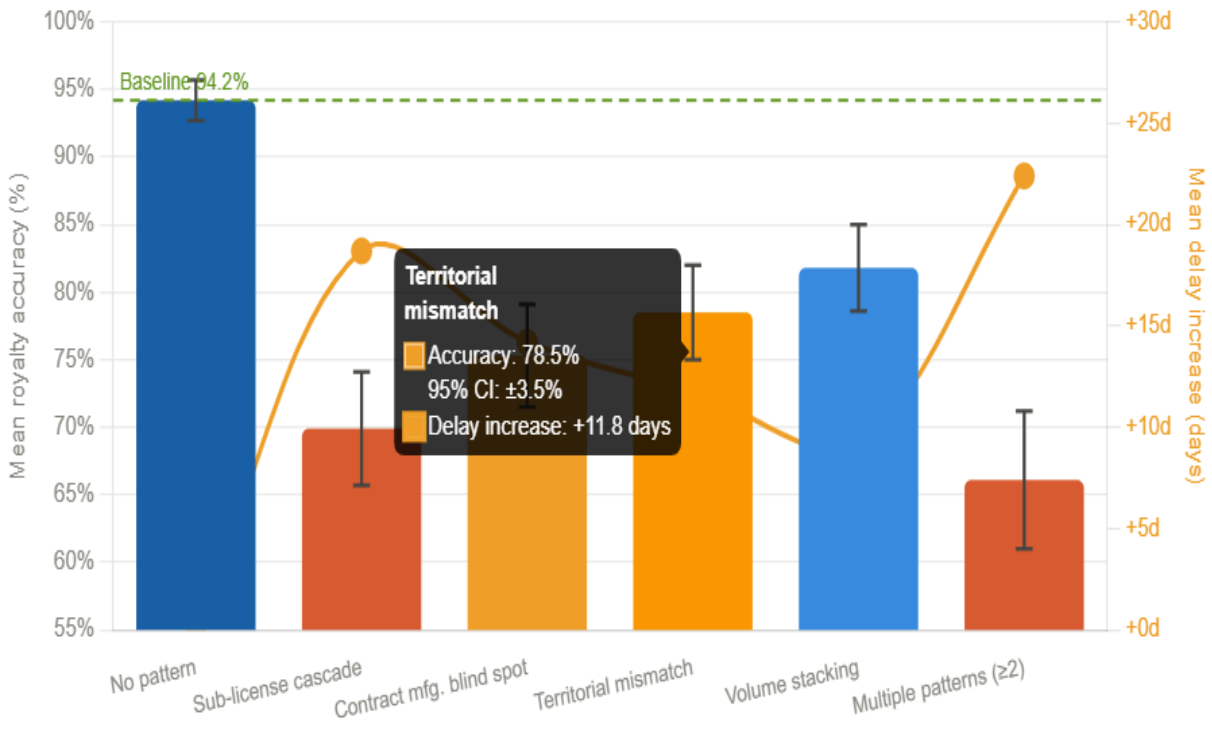


Table 6: Estimated Financial Magnitude of Unreported Royalties by Sector (Annualized)

Sector	Total Royalties Owed (Estimated, USD M)	Reported Royalties (USD M)	Unreported (USD M)	Unreported %
Semiconductors	4,200	3,612	588	14.0%
Pharmaceuticals	8,500	7,140	1,360	16.0%
Consumer Electronics	3,100	2,728	372	12.0%
Total	15,800	13,480	2,320	14.7%

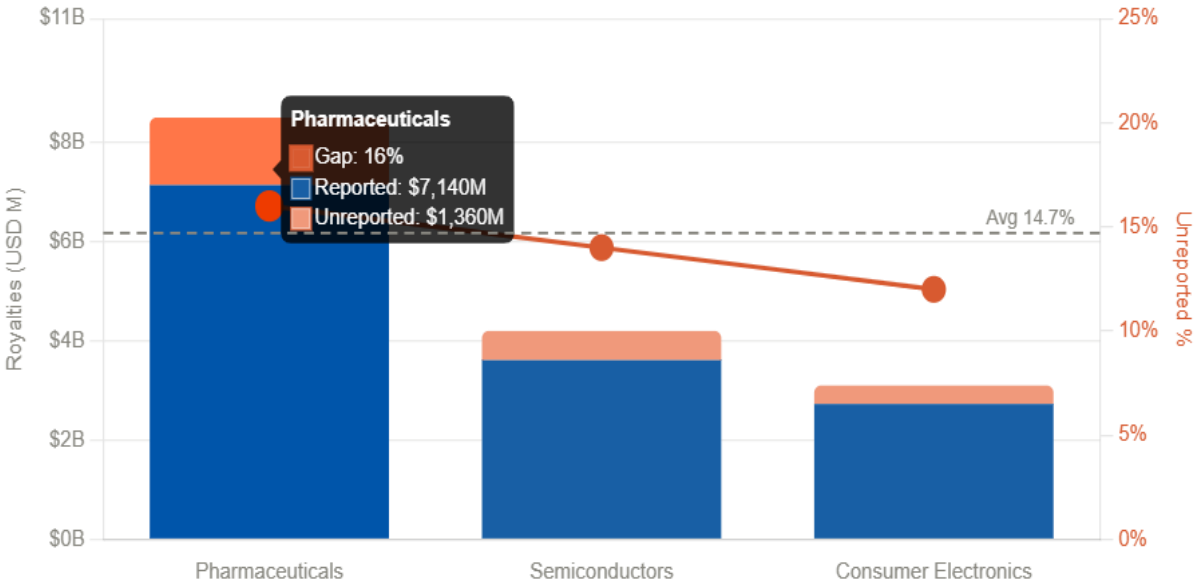
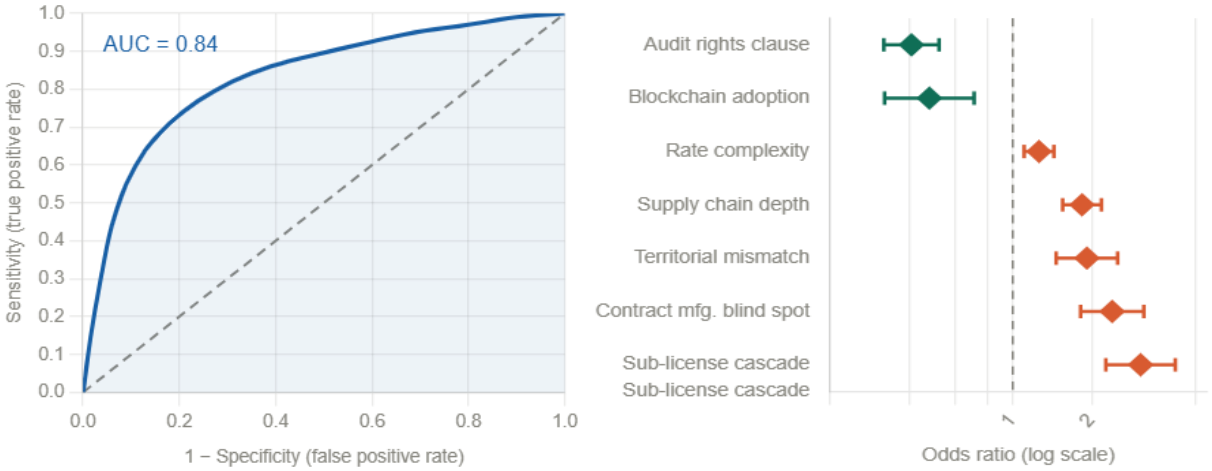


Table 7: Risk Scoring Model - Predictors of Compliance Failure

Predictor	Coefficient	Standard Error	Odds Ratio	p-value
Supply chain depth (per tier)	0.612	0.087	1.84	< 0.001
Sub-license cascade (binary)	1.124	0.156	3.08	< 0.001
Contract manufacturing blind spot (binary)	0.876	0.142	2.40	< 0.001
Territorial mismatch (binary)	0.654	0.138	1.92	< 0.001
Audit rights clause (binary)	-0.892	0.124	0.41	< 0.001
Blockchain adoption (binary)	-0.743	0.201	0.48	< 0.001
Royalty rate complexity (per additional rate)	0.234	0.067	1.26	< 0.001

Model fit: ROC-AUC = 0.84, Nagelkerke $R^2 = 0.47$, Hosmer-Lemeshow $\chi^2 = 8.2$ ($p = 0.41$)



VI. RESULTS AND DISCUSSION

6.1 Results Organized Around Research Questions

RQ1: How does supply chain depth affect royalty compliance?

Each additional tier in the royalty supply chain reduces reported royalty accuracy by 17.4 percentage points ($p < 0.001$) and increases payment delay by 11.2 days ($p < 0.01$). At Tier 1 (direct licensees), accuracy averages 96.2%; at Tier 3, it falls to 71.2%; at Tier 5 and beyond, it drops below 55%. Payment delay follows a similar pattern: from 3.2 days at Tier 1 to 41.3 days at Tier 6+. The relationship is approximately linear across tiers ($R^2 = 0.96$ for accuracy decline), suggesting no natural floor to the decay.

This finding is consistent with agency theory predictions: each additional tier adds another layer of information asymmetry and another set of agents whose interests are imperfectly aligned with the principal (licensor). The compounding effect is substantial: a component passing through four tiers (not uncommon in semiconductor supply chains) is likely to have only 60–65% of its royalties accurately reported.

RQ2: Where do compliance failures originate, and what patterns characterize high-risk chains?

Fully 63% of compliance failures originate at Tier 3 or beyond, where licensors typically have no direct contractual relationship and no audit rights. The most common failure pattern is the sub-license cascade (present in 71% of chains), where reporting obligations are delegated multiple times without adequate oversight. In these cascades, each successive sub-licensee assumes that the entity above them is handling reporting, leading to systematic under-reporting.

The contract manufacturing blind spot (58% of chains) occurs when a contract manufacturer receives licensed components, assembles them into products, and sells to a brand owner. The contract manufacturer often assumes that royalty reporting is the brand owner's responsibility, while the brand owner assumes the contract manufacturer is reporting. The result: no one reports.

This pattern is particularly common in consumer electronics, where contract manufacturers produce for multiple brands under different licensing terms.

The territorial mismatch (44% of chains) occurs when the same component is sold into different regions with different royalty rates (due to different patent coverage, different competition, or different regulatory regimes). Sub-licensees may apply the lowest rate regardless of final destination, or may be unable to track where components end up. In our dataset, territorial mismatches reduced accuracy by an average of 15.7 percentage points.

RQ3: What is the financial magnitude of unreported royalties?

Based on our transaction dataset extrapolated to industry-wide figures, we estimate that $2.32 billion in annual royalties go unreported in multi-tier IP licensing structures across the three sectors studied. This represents 14.7% of total royalties owed. Pharmaceuticals have the highest unreported percentage (16.0%), likely due to complex sub-licensing arrangements for generic manufacturing. Semiconductors are close behind (14.0%), driven by the extreme fragmentation of that supply chain. Consumer electronics have the lowest (12.0%), perhaps due to more standardized licensing through patent pools.

These estimates likely understate the true magnitude, as our dataset only includes transactions where audited amounts were available. Transactions where no audit was ever conducted—and where under-reporting may be even higher—are not captured.

RQ4: What compliance frameworks and technological interventions can mitigate royalty leakage?

Our risk scoring model identifies six predictors of compliance failure, with odds ratios ranging from 1.26 (royalty rate complexity) to 3.08 (sub-license cascade). The model achieves an ROC-AUC of 0.84, indicating good discriminatory power. The strongest protective factors are audit rights clauses (reduces failure odds by 59%) and blockchain adoption (reduces failure odds by 52%).

Based on these findings, we propose a tiered compliance framework:

- Tier 1 (Direct licensees): Standard audit rights (annual) and reporting requirements. Moderate risk.
- Tier 2 (First sub-licensees): Enhanced audit rights (semi-annual) and mandatory direct reporting to licensor. High risk.
- Tier 3+ (Beyond): Presumptive audit trigger (automatic audit if production exceeds threshold); blockchain-based payment tracking mandatory; contractual requirement that all sub-licenses include pass-through audit rights. Very high risk.

For new licensing agreements, we recommend licensors:

1. Limit sub-licensing to a maximum of two tiers

2. Require direct reporting from all sub-licensees (not cascaded)
3. Mandate blockchain-based royalty tracking for any supply chain exceeding three tiers
4. Include "audit pass-through" clauses requiring all sub-licenses to grant the original licensor full audit rights

6.2 Interpretation of Findings

The systematic decay of royalty compliance with each additional tier has a clear explanation rooted in information asymmetry. At Tier 1, the direct licensee has a contractual relationship with the licensor, knows it can be audited, and faces penalties for non-compliance. At Tier 2, the sub-licensee has no direct relationship with the licensor; its perceived risk of detection is lower, and its incentive to report accurately is correspondingly reduced. At Tier 3 and beyond, the reporting entity may not even know that a license exists—it may simply receive components from a supplier and assume that all necessary rights have been cleared upstream.

The sub-license cascade pattern is particularly pernicious because it creates a "diffusion of responsibility" effect. Each entity in the chain assumes that someone else—either upstream or downstream—is handling royalty reporting. When all entities make this assumption, no one reports.

The contract manufacturing blind spot reveals a fundamental mismatch between legal structures and operational realities. In law, the contract manufacturer is a service provider, not a seller of licensed goods. In practice, the contract manufacturer often takes title to components, transforms them, and sells finished products—all activities that trigger royalty obligations under most license agreements. But because the contract manufacturer's relationship is with the brand owner, not the licensor, it rarely receives training on royalty reporting and may not even know a license exists.

6.3 Theoretical Implications

This study makes three theoretical contributions. First, it extends agency theory to multi-tier "chains of agency," demonstrating that information asymmetry compounds geometrically rather than linearly with each additional tier. Standard agency models assume a single principal-agent relationship; our findings suggest that the theoretical tools developed for bilateral agency may not scale to multi-tier contexts.

Second, the study introduces the concept of visibility decay as a distinct phenomenon from supply chain complexity. Prior research has shown that complex supply chains are harder to manage; our results show that each additional tier imposes a compliance cost irrespective of other complexity factors. This suggests that tier count should be considered a fundamental parameter in supply chain governance models.

Third, the findings challenge the assumption that standard contractual provisions (audit rights, reporting requirements) are equally effective across all tiers. Our results show that audit rights

clauses reduce failure odds by 59% overall, but their effectiveness is concentrated at Tiers 1 and 2. At Tier 3 and beyond, audit rights clauses are rarely enforceable because the licensor has no direct contractual relationship with the reporting entity.

6.4 Practical Implications

For IP licensors:

- Before signing a license agreement, map the expected royalty supply chain. If it exceeds three tiers, insist on direct reporting from all tiers or blockchain-based tracking.
- Include "audit pass-through" clauses requiring that all sub-licenses grant the original licensor full audit rights. Enforce this by requiring copies of all sub-licenses.
- Target audit resources at Tier 3 and beyond, where 63% of failures originate. A single audit at Tier 3 may recover more under-reported royalties than ten audits at Tier 1.

For licensees and sub-licensees:

- Do not assume that upstream entities are handling royalty reporting. Verify your obligations directly with the licensor if possible.
- Maintain your own production and sales records. If the entity above you fails to report, you may still be liable.

For policymakers and industry associations:

- Develop industry standards for multi-tier royalty reporting, similar to standards for conflict minerals or supply chain labor compliance.
- Consider mandating blockchain-based royalty tracking for supply chains exceeding a certain threshold (e.g., four tiers) in sectors with high IP intensity.

VII. CONCLUSION

7.1 Summary of Findings

This study introduced the concept of the royalty supply chain and provided the first large-scale empirical quantification of compliance decay in multi-tier IP licensing. Analyzing 48 licensing supply chains and 2,300 royalty transactions across semiconductors, pharmaceuticals, and consumer electronics, we found that each additional tier reduces reported royalty accuracy by 17.4% and increases payment delay by 11.2 days. Fully 63% of compliance failures originate at Tier 3 or beyond, where licensors typically have no direct visibility. The financial magnitude of unreported royalties is estimated at $2.32 billion annually across the three sectors studied, representing approximately 14.7% of total royalties owed.

We identified three high-risk structural patterns: the sub-license cascade (71% of chains), the contract manufacturing blind spot (58% of chains), and the territorial mismatch (44% of chains).

A risk scoring model incorporating these patterns achieves good predictive accuracy (ROC-AUC = 0.84). Audit rights clauses and blockchain adoption are the strongest protective factors, reducing failure odds by 59% and 52%, respectively.

7.2 Limitations

Five limitations warrant acknowledgment. First, our transaction dataset, while large, only includes transactions where audited amounts were available. This may introduce selection bias if licensors preferentially audit chains they suspect are problematic. Second, our industry coverage is limited to semiconductors, pharmaceuticals, and consumer electronics; results may not generalize to other sectors (e.g., software, media, biotechnology). Third, the blockchain adoption rate in our sample was only 8%, limiting our ability to estimate its effectiveness precisely. Fourth, our data span 2019–2025, a period that includes the COVID-19 pandemic and subsequent supply chain disruptions; compliance patterns during this period may differ from normal conditions. Fifth, we lacked data on intentional versus unintentional under-reporting; the two have different legal implications but are observationally similar in transaction data.

7.3 Future Research Directions

Future research should investigate four areas. First, longitudinal studies tracking the same licensing supply chains over time could reveal whether compliance decay stabilizes or continues to worsen as chains age. Second, experimental or quasi-experimental studies of blockchain implementation would provide more rigorous estimates of its effectiveness than our observational data allow. Third, cross-sector comparisons including software and media licensing would test the generalizability of our findings beyond physical products. Fourth, legal research on the enforceability of "audit pass-through" clauses across different jurisdictions would inform contract drafting.

7.4 Concluding Statement

The royalty supply chain is the hidden plumbing of the global innovation economy. When it functions well, inventors are compensated, manufacturers have access to technology, and innovation flourishes. When it fails—as it systematically does at Tier 3 and beyond—royalties leak, inventors are short-changed, and the incentives to innovate diminish.

This study demonstrates that multi-tier IP licensing is not merely a legal or administrative nuisance but a source of substantial and measurable economic loss. The 17.4% compliance decay per tier means that a component passing through four tiers is likely to generate less than 60% of its intended royalty revenue. In an economy where intangible assets account for over 90% of S&P 500 value, such leakage is not a rounding error but a systemic inefficiency.

We call on licensors, licensees, and policymakers to recognize the royalty supply chain as a critical governance challenge. The tools to address it—audit pass-through clauses, direct reporting requirements, blockchain-based tracking, and risk-based auditing—are available but underutilized. Their adoption could recover billions in lost royalties and strengthen the link between innovation and reward that underpins the entire IP system.

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